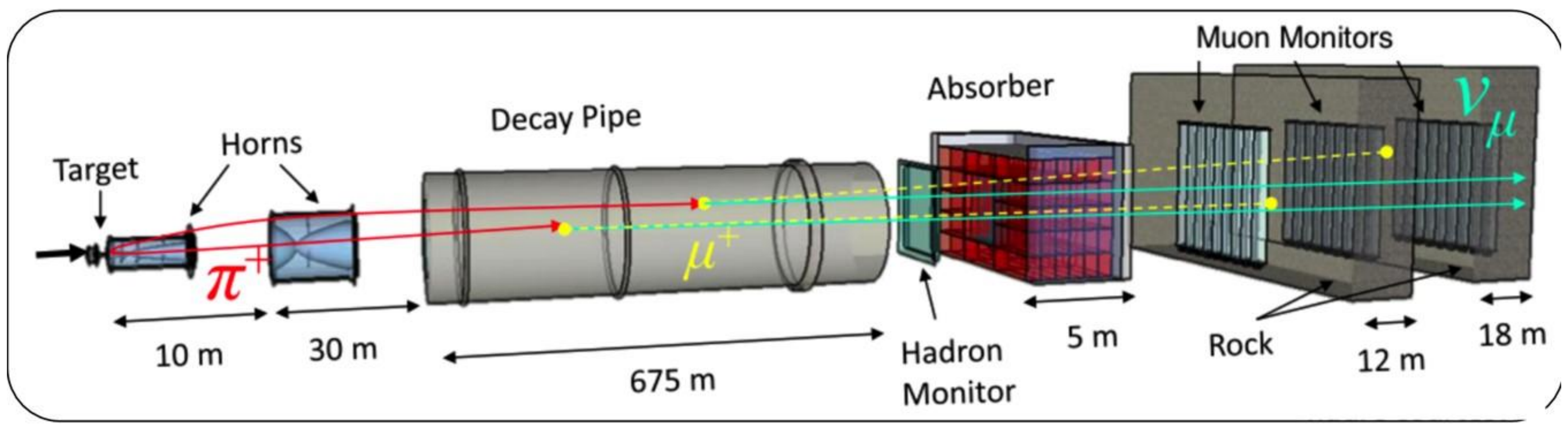
Data Acquisition System for an RF Cavity Hadron Monitor

Kyle Leleux, University of Louisiana at Lafayette
Katsuya Yonehara, Fermilab

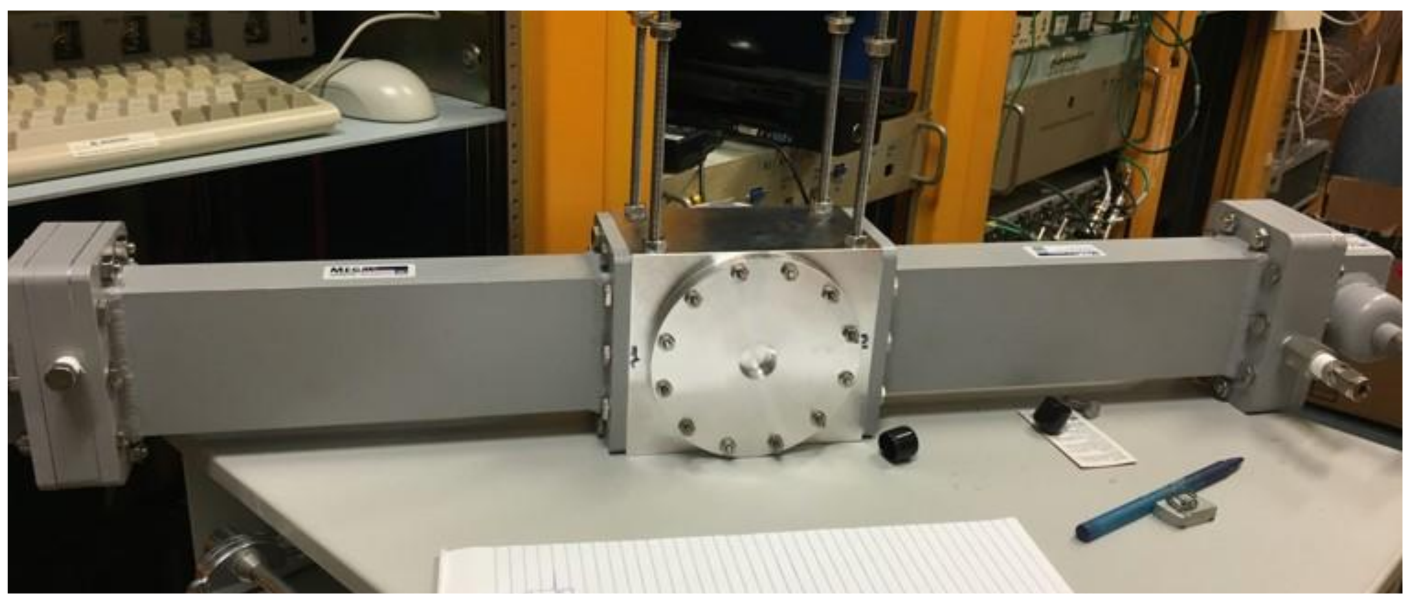
August 8, 2019
FERMILAB-POSTER-19-094-AD

Abstract

As Fermilab pursues intensity frontier physics, the conventional detectors are not up to the challenge of higher radiation exposure. The detectors in the NuMI beamline rely on knowing the beam composition in order to infer properties of the resultant neutrino beam. A novel gas-filled RF cavity beam detector is proposed that will be simple and radiation robust in high-radiation environments. Charged particles passing through the cavity produce ionized plasma, which changes the permittivity of the gas and modulate the stored RF field in the cavity. The recent preliminary beam result demonstrates the proof of principle of the beam detector. In an effort to acquire a large amount of data for various cavity parameters, an automatic data acquisition (DAQ) system is designed in LabVIEW. The DAQ system utilizes a Real-Time Power meter from Boonton to acquire RF power data from the cavity.

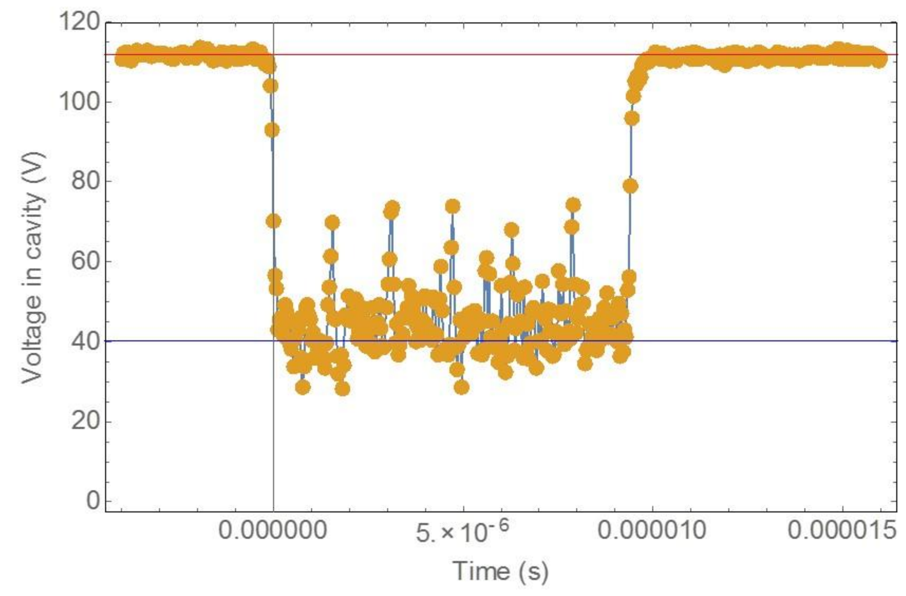


NuMI Target Chamber Schematic [1]



RF Cavity Prototype [2]

Boonton RF Power Meter

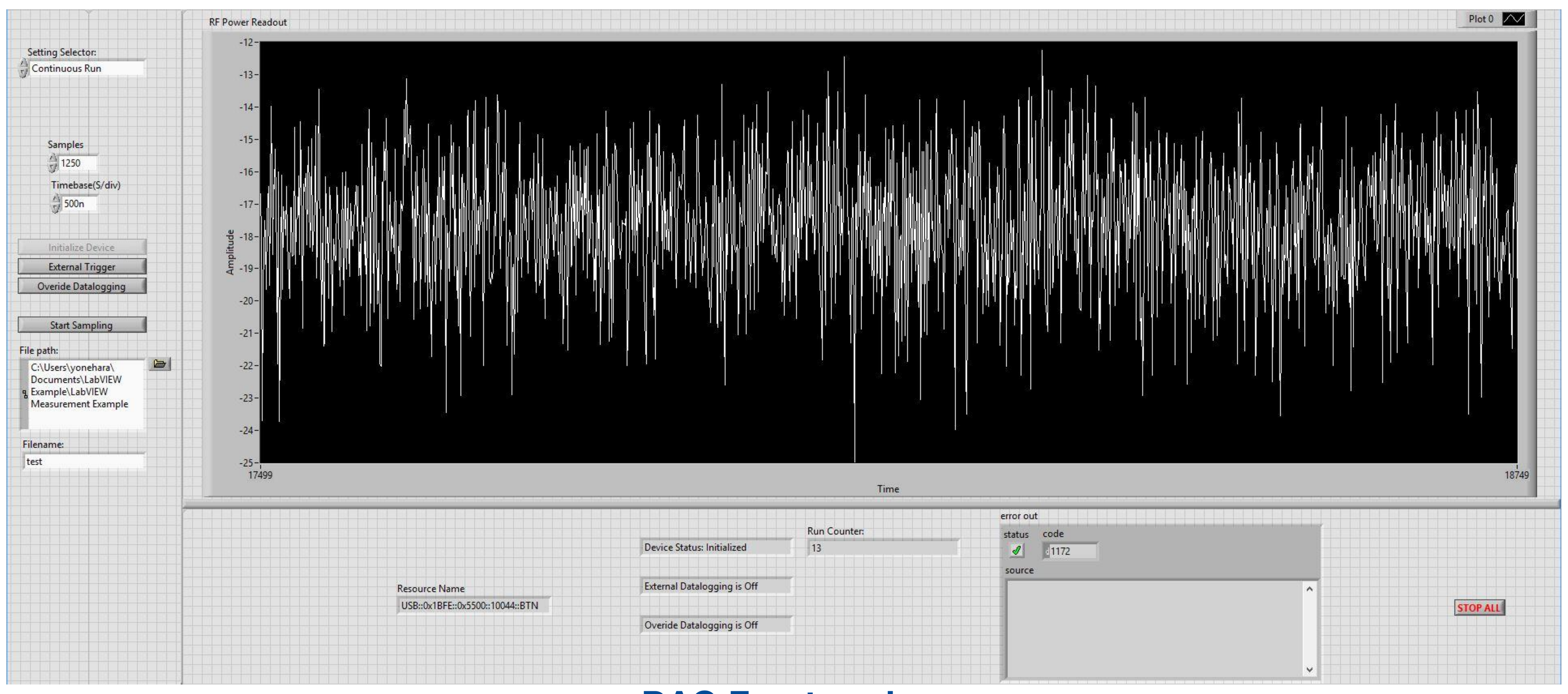


Beam-RF Cavity Interaction Waveform [2]

Principles of DAQ

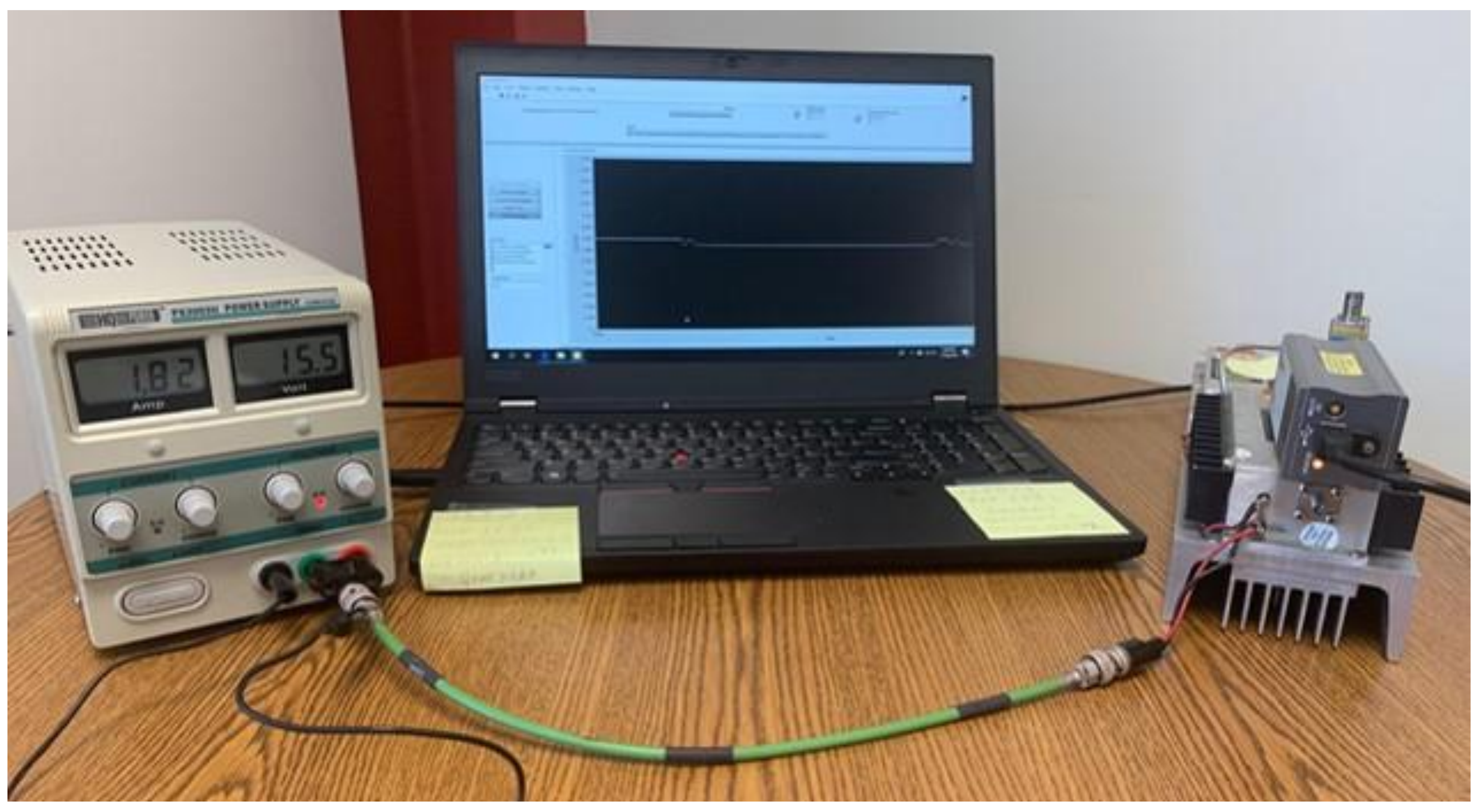
An aluminum 2.4GHz gas-filled RF cavity beam detector is built as the test cavity. The gas ionizes upon contact with the beam, which results in a drop of the RF power in the cavity. This drop in RF power is proportional to the incident beam at equilibrium condition. A new DAQ system records a time-domain RF envelope which is sent from the Real-Time RF Power meter (RTP). The DAQ is triggered by the Fermilab accelerator clock time to take the beam-loaded RF envelope. When the beam is turned off, the DAQ also turns off the RF power input to take the quality factor of the cavity by measuring the decay time constant of the stored RF field in the cavity. The input RF power and driving frequency are controlled by LabView to maximize the quality factor.

Front-end and Benchtop Setup

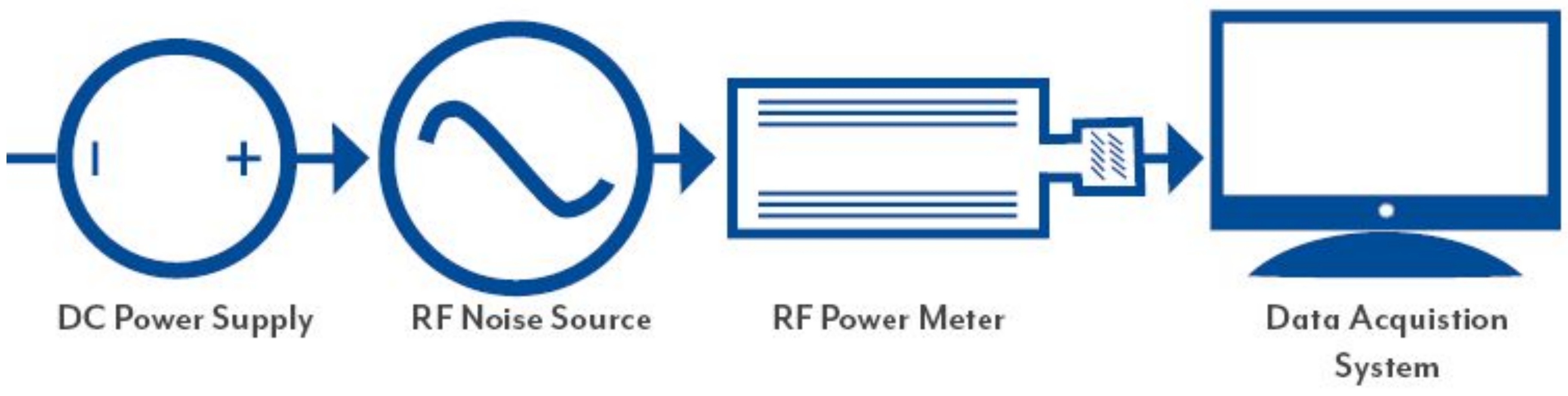


DAQ Front-end

Data Flow Process [3]



Benchtop Setup



Benchtop Setup Process Flow Diagram [3]

Future Work

Future development of DAQ system includes a focus on control. Temperature rises due to plasma generation change the resonant frequency of the cavity. Future accommodations are necessary to monitor off-center beam analysis for position dependent beam profile measurements. Future studies are also needed to study position dependent and time distribution for time differential analysis, which helps eliminate systematic errors.

References

[1] Yonehara, Katsuya. "Progress of RF beam detector R&D." 16 05 2019.

[2]Yonehara, Katsuya, et al. "Pressurized Gas Beam Monitor for Extremely High Intensities." 2019.

[3] Graphic Design by LiAnne Dick

This manuscript has been authored by Fermi Research Alliance, LLC under Contract No. DE-AC02-07CH11359 with the US. Department of Energy, Office of Science, Office of High Energy Physics.